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THE MACAL RIVER: A FLORISTIC AND PHYTOSOCIOLOGICAL STUDY OF A THREATENED RIVERINE VEGETATION COMMUNITY IN BELIZE

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A species checklist is presented for a stretch of the seasonally flooded Macal River in the Cayo District of Belize, together with preliminary phytosociological data for the primary riverine communities. A total of 229 species were recorded in the seasonally flooded riparian zone, representing 7% of the flora of Belize. Results of quantitative sampling indicate that *Inga vera* subsp. *vera* dominates the river corridor. Other important woody associates include *Cuphea calophylla*, *C. utriculosa*, *Calyptranthes bartlettii*, *C. lindeniana*, *Lindenia rivalis*, *Pleuranthodendron lindenii*, *Calliandra tergemina* and *Nectandra salicifolia*. One of the most significant threats to riparian vegetation in the region is the Chalillo Dam upstream of the study site. The current work provides baseline floristic and ecological data for this threatened riparian habitat and documents the structure and composition of vegetation that exists downstream from the dam before its construction.

Keywords. Belize, Chalillo Dam, floristics, Macal River, Maya Mountains, phytosociology, riparian vegetation, riverine community.

INTRODUCTION

Many different terms are used to refer to vegetation found along the banks of running fresh waters. These include riparian vegetation (Decamps & Tabacchi, 1994), gallery forest, and streamside forests (Brinson, 1990). Although terminology differs, riparian vegetation can be loosely defined as the flora that grows in the transition region between aquatic and terrestrial environments along freshwater rivers and streams. It is the nature of the hydrological regime that distinguishes the riparian zone from its surroundings (Malanson, 1993), with its structure, composition and dynamics shaped by river-related processes such as inundation, the transportation of sediment, and the erosive and abrasive forces of water (Brinson, 1990).

Riparian vegetation zones are often notably species-rich habitats and are responsible for higher rates of biomass production when compared with other adjacent forest communities (Brinson, 1990; Decamps & Tabacchi, 1994). Their high species diversity is due in part to floods. These can create a mosaic of microhabitats within which numerous plant species coexist (Swanson *et al.*, 1988; Gregory *et al.*, 1991).

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Riparian landscapes are highly threatened ecosystems as they are inherently rare habitats, occupying a mere one-thousandth of the earth's surface (Hynes, 1970).

The majority of studies on riparian vegetation have been conducted in northern temperate regions, with only a small body of work carried out in tropical ecosystems. Consequently, riparian ecosystems in the Neotropics remain poorly known, with little published work available on their floristic composition and ecological structure. With regard to Belize, the majority of published research on riparian forests has focused on those traversing pine-savanna areas (Meave *et al.*, 1991; Macdougall & Kellman, 1992; Kellman & Tackaberry, 1993; Kellman & Meave, 1997; Kellman *et al.*, 1998; Pither & Kellman, 2002). This has largely focused on understanding the extent to which specific environmental factors influence the structure and composition of these ecosystems. Such studies do not usually involve detailed floristic inventories, although riparian corridors in the pine-savanna of Belize are postulated as areas of high species diversity, and are thought to play prominent roles in maintaining regional biodiversity (Meave *et al.*, 1991; Kellman *et al.*, 1998; Pither & Kellman, 2002).

The Macal River Watershed is regarded as one of the most biologically diverse watersheds remaining in Central America (Minty, 2001). Studies have shown that it provides important habitats for rare and endangered species such as the Scarlet Macaw, Baird's Tapir, and the Morelet Crocodile (Meerman & Sabido, 2001). Recently, the construction of a hydroelectric dam on the river at Chalillo has caused widespread concern (Minty, 2001). The dam has resulted in an estimated loss of 18 km of riverine habitat on the Macal and another 15 km on one of its tributaries (the Rascapulo). Although the riverine vegetation is regarded as biologically rich and is currently threatened, no detailed floristic information is available.

The present study provides a floristic checklist for a stretch of riparian corridor along the Macal River. In addition, preliminary phytosociological data for this habitat are presented, together with brief floristic notes on the woody flora of an oak-dominated savanna occurring in the uplands adjacent to the riparian corridor beside the study site.

Study area

The study focused on a 1.5 km stretch of the Macal River centred upon the Guacamallo Bridge (16°44′00″N, 88°59′17″W). The Macal River runs through the Cayo District of southwestern Belize and is part of the Belize River Watershed which eventually flows eastward to Belize City where it enters the Caribbean Sea (Fig. 1). The area has a subtropical climate typical of the region, with a dry season lasting from February to May during which monthly rainfall averages less than 100 mm (Harcourt & Sayer, 1996). The vast majority of precipitation falls in the wet season from approximately June until January. The onset of the wet season corresponds to seasonal floods that characterize the hydraulic regime of the river.

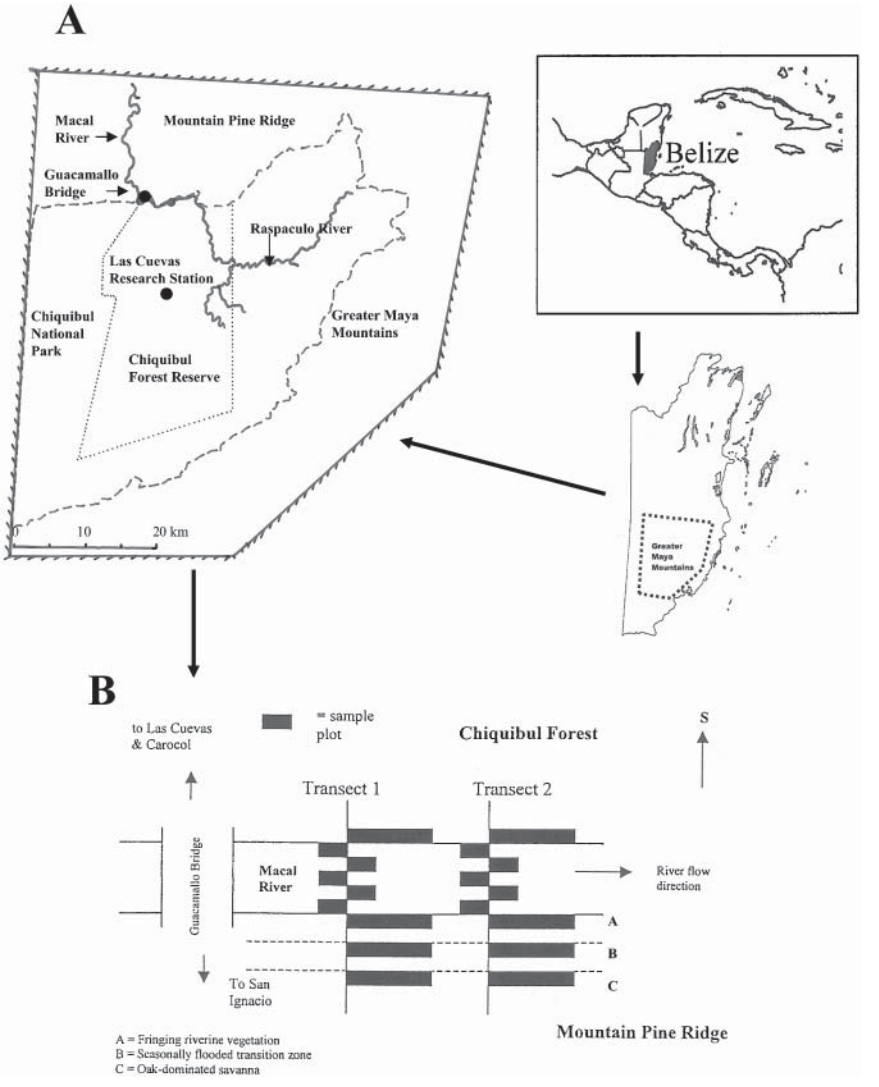

FIG. 1. A, Map of Belize showing its location in Central America, the location of the Greater Maya Mountains within Belize, and the location of the study site within the Greater Maya Mountains. B, Diagram of the study site showing the location of the transects on the Macal River below Guacamallo Bridge, and the position of the quantitative plots.

The substrate of the riverbed adjacent to Guacamallo Bridge alternates between limestone and granite rocks of the Mountain Pine Ridge. Smaller amounts of sedimentary and volcanic rock are also found in the channel. Geological heterogeneity of the river channel at the study site results from its position between two geologically distinct regions. The upland bedrock on the right (downstream) bank of the

study sites comprises nutrient-poor granite of the Mountain Pine Ridge, whilst the bedrock of the uplands on the left (downstream) bank is limestone. Thus, the Macal River essentially lies on a boundary between the oak- and pine-dominated savanna of the Mountain Pine Ridge to the north and east, and the semi-deciduous tropical forest of the Chiquibul Reserve to the south. The contrast between these two vegetation types is floristically and structurally striking.

The first vegetation classification of Belize was conducted by the Land Survey Team (Wright *et al*., 1959), who classified the vegetation along the Macal River as 'Cohune-Banak Forest' nested within a broader vegetation classification defined as 'Broadleaf Forest with Occasional Lime-Loving Species'. Characteristic species cited for this vegetation type include *Attalea cohune* Mart., *Virola koschnyi* Warb., *Schizolobium parahyba* (Vell.) S.F.Blake, *Ceiba pentandra* (L.) Gaertn. and *Ficus ovalis* (Liebm.) Miq. According to a later classification (Iremonger & Brokaw, 1995) the same vegetation was classified as 'Disturbed Scrub'. Meerman & Sabido (2001) identify vegetation along the Macal River as 'Deciduous Broadleaf Lowland Riparian Shrubland in Hills'. This classification is based on standardized UNESCO terminology and is accompanied by a species list of 31 taxa. In another recent vegetation map of the Maya Mountains in Belize (Penn *et al.*, 2004), the same vegetation is classified as 'Riverine Forest (Class 16)' with *Inga vera* Willd. mentioned as being dominant in the most frequently flooded areas.

Methods

A five-week floristic survey of a stretch of the Macal River was made towards the end of the dry season (April–May 2003) when the channel was almost dry. An inventory was compiled through intensive collecting in an area approximately 1.5 km long and centred upon the Guacamallo Bridge. The species list was subsequently supplemented with 26 extra species records from specimens lodged in the herbaria of the Missouri Botanical Garden (MO), although these specimens have not been seen by the authors. Only specimens known to have been collected from within the riverine corridor at the site were included. Voucher material was not collected for 13 species. These comprised common species well known to the authors. In addition, a checklist of the woody species occurring in the oak-dominated savanna adjacent to the river was compiled. Herbarium specimens were made in sets of five with duplicates deposited at the Royal Botanic Garden Edinburgh (E), the Natural History Museum, London (BM), the Missouri Botanical Garden (MO) and the Forestry Department, Ministry of Natural Resources, Belmopan, Belize (BRH). Specimens were identified using available literature, and by comparison of the collections with specimens at BM, E and BRH. In addition, determinations for a few families were provided by specialists (see Acknowledgements).

Based on marked structural and floristic differences between zones, four distinct vegetation types within the slope of the river valley were recognized. These comprised:

(i) vegetation in the river channel;
(ii) fringing riverine vegetation;
(iii) transition vegetation between riverine and upland communities;
(iv) oak-dominated savanna.

Within each of these recognized zones stratified sampling was carried out. The purpose of the quantitative sampling was to provide preliminary data on vegetation structure.

For sampling, two transect lines selected as representative of the general vegetation were placed across the river at right angles to its course. The locations of both transect lines were recorded using GPS at the deepest points of the river bed (16°52′07″N, 89°02′62″W for Transect 1; 16°44′00″N, 89°59′17″W for Transect 2). Plots adjacent to the transect lines were placed subjectively within each of the clearly recognized vegetation associations (Fig. 1). Within the river channel five 50×50 m quadrats were established adjacent to each of the two transect lines across the river, with the long side parallel to the channel. The total of 10 plots gave a survey area of 0.5 ha. In each plot, the numbers of all woody and herbaceous species were recorded and their frequencies calculated.

In the fringing riverine vegetation association three plots measuring 25×5 m were established on either side of the riverbank adjacent to both transect lines with their long sides parallel to the river (Fig. 1). Thus, a total of 0.15 ha was surveyed. The diameter and height of all woody species ≥ 10 cm in diameter at 30 cm above ground level were recorded. The decision to record diameter at 30 cm instead of the more conventional breast height (1.3 m above ground level) was made because tree and shrub species in this zone tend to be multi-branched at low levels. In the seasonally flooded transitional zone between the fringing riverine vegetation association and the upland oak-dominated savanna on the downstream right bank side of the river, three plots measuring 25×10 m were established adjacent to the transect lines, giving a total area of 0.15 ha. Diameter at breast height (dbh) and height were recorded for all individuals ≥ 10 cm dbh. In the oak-dominated savanna a total of six plots (50×10 m) were established (representing a total area of 0.3 ha), with three plots situated adjacent to each transect. The height and dbh of all individuals ≥ 10 cm dbh were recorded within these plots. Voucher material was collected of all species recorded. Phytosociological data were analysed using the software program FITOPAC (Shepherd, 1995).

Results

A species list for riverine vegetation and the oak-dominated savanna occurring within the study area is provided in the Appendix. Those species collected during the current survey and those derived from pre-existing herbaria records are clearly identified by the cited specimens. All specimens from this study were collected by Lillis Urban. The Appendix lists species authors, and so these are not repeated again in the text henceforth. Frequency data for species occurring on rocks within the river

channel are presented in Table 1. Phytosociological data are given for the fringing riverine vegetation in Table 2, for the transitional riverine association in Table 3 and for the oak-dominated savanna in Table 4.

Species list

A total of 345 specimens were collected in the riverine habitat, representing 229 species. Of these, 205 taxa (89.5%) were identified to species level, 22 (9.5%) only to genus level and 2 (1%) only to family level. This list was supplemented by a further 26 records (to species level) from specimen data collated from the herbaria of Missouri (MO), the Natural History Museum (BM) and the Royal Botanic Garden Edinburgh (E). In the oak-dominated savanna eight woody species were recorded. Two of the species collected are endemic to Belize. The first, *Calyptranthes bartlettii*, grows on islands in the river channel and in the fringing riverine vegetation. *Dalechampia shippii* was collected in the oak woodland, although detailed collections were not made of the herbaceous flora of this vegetation type.

Quantitative sampling

Vegetation in the river channel is sparse and the majority of recorded taxa are herbaceous ruderals or small shrubs confined to sandy inlets in the channel and crevices in boulders. Only eight of the 27 species found in the river channel are woody; all are less than 1.5 m in height. The primary woody species comprise: *Cuphea calophylla*, *C. utriculosa*, *Inga vera* subsp. *vera*, *Calyptranthes bartlettii*, *Lindenia rivalis*, *Calliandra tergemina*, *Mimosa pellita* and *Serjania lundellii*. Characteristic non-woody taxa are *Spermacoce verticillata*, *Arundinella berteroniana*, *Symphyotrichum expansum* and *Polygala paniculata*. In addition, *Najas wrightiana* and *Marathrum* sp. were commonly observed growing on inundated rocks within the river itself.

The fringing riverine vegetation community comprised a species-rich dense thicket to 3 m, dominated by *Inga vera* subsp. *vera* which has by far the greatest importance value index (IVI = 95.17). *Calyptranthes lindeniana* has the second highest IVI of species sampled (IVI = 23.23). Other relatively common and abundant woody species in the association include *Pleuranthodendron lindenii*, *Lonchocarpus* sp. 1 (*Urban* 255), *Nectandra salicifolia*, *Ficus insipida* and *Casearia corymbosa*. Twelve of the 35 species recorded in the quantitative plots are represented by one individual only.

In the forest scrub transition association, a total of 81 individuals representing 23 species were recorded, with the palm *Astrocaryum mexicanum* showing the highest IVI of all species (IVI = 40.87). Other characteristic species of the association include *Spondias mombin*, *Ateleia gummifera*, *Cochlospermum vitifolium*, *Zuelania guidonia*, *Andira inermis* subsp. *inermis*, *Bursera simaruba* and *Vitex gaumeri*. One third of all species sampled are represented by a single individual.

TABLE 1. Species recorded on the rocks and sandy inlets in the river channel

Species	Family	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	AFreq. (%)
Cuphea calophylla	*Lythraceae*	X	X	X	X	X	X	X	X			80
Cuphea utriculosa	*Lythraceae*	X	X	X	X	X	X		X			70
Inga vera subsp. *vera*	*Fabaceae – Mimosoideae*	X	X	X	X	X	X	X				70
Eleocharis retroflexa	*Cyperaceae*		X	X	X	X	X		X			60
Spermacoce verticillata	*Rubiaceae*	X	X	X	X	X						50
Arundinella berteroniana	*Poaceae*	X		X		X	X	X				50
Calyptranthes bartlettii	*Myrtaceae*	X	X		X	X		X				50
Symphyotrichum expansum	*Asteraceae*	X	X		X		X	X				50
Lindenia rivalis	*Rubiaceae*	X	X	X		X						40
Polygala paniculata	*Polygalaceae*	X	X					X				30
Hymenachne amplexicaulis	*Poaceae*	X					X		X			30
Bauhinia sp. (*Urban* 30)	*Fabaceae – Caesalpinioideae*						X	X	X			30
Fimbristylis dichotoma	*Cyperaceae*				X			X	X			30
Phyllanthus cf. *compressus* (*Urban* 366)	*Phyllanthaceae*				X			X	X			30
Panicum laxum	*Poaceae*				X			X	X			30
Ludwigia octovalis	*Onagraceae*				X				X			20
Euphorbiaceae sp. (*Urban* 91)	*Euphorbiaceae*				X				X			20
Mecardonia procumbens	*Plantaginaceae*	X										10
Lobelia cardinalis	*Campanulaceae*		X									10
Pilea microphylla	*Urticaceae*		X									10
Serjania lundellii	*Sapindaceae*				X							10
Eragrostis sp. (*Urban* 363)	*Poaceae*				X							10
Selaginella pallescens	*Selaginellaceae*				X							10
Ipomoea cf. *umbraticola*	*Convolvulaceae*					X						10
Cyperus digitatus	*Cyperaceae*							X				10
Scleria cf. *melaleuca*	*Cyperaceae*							X				10
Mimosa pellita	*Fabaceae – Mimosoideae*								X			10

P1, Plot 1; P2, Plot 2; P3, Plot 3, etc.; AFreq., absolute frequency.

TABLE 2. Fringing riverine vegetation: Phytosociological data

Species	Family	Density			Dominance		Frequency		
		Ind.	ADen.	RDen.	ADo.	RelD.	AFreq.	RelF.	IVI
Inga vera subsp. *vera*	*Fabaceae – Mimosoideae*	54	360.0	21.69	24.91	62.12	83.33	11.36	95.17
Calyptranthes lindeniana	*Myrtaceae*	21	140.0	8.43	2.29	5.71	66.67	9.09	23.23
Pleuranthodendron lindenii	*Salicaceae*	29	193.3	11.65	2.58	6.44	25.00	3.41	21.49
Lonchocarpus sp. (*Urban* 255)	*Fabaceae – Faboideae*	19	126.7	7.63	1.57	3.91	66.67	9.09	20.63
Chrysophyllum mexicanum	*Sapotaceae*	13	86.7	5.22	0.74	1.85	33.34	4.54	11.61
Nectandra salicifolia	*Lauraceae*	8	53.3	3.21	0.39	0.96	41.67	5.68	9.86
Ficus insipida	*Moraceae*	7	46.7	2.81	0.98	2.44	33.33	4.55	9.79
Casearia corymbosa	*Salicaceae*	12	80.0	4.82	0.58	1.46	25.00	3.41	9.68
Randia lundelliana	*Rubiaceae*	12	80.0	4.82	1.02	2.54	16.67	2.27	9.64
Calliandra tergemina	*Fabaceae – Mimosoideae*	10	66.7	4.02	0.93	2.32	16.67	2.27	8.61
Andira inermis subsp. *inermis*	*Fabaceae – Faboideae*	5	33.3	2.01	0.29	0.73	33.33	4.55	7.28
Adelia barbinervis	*Euphorbiaceae*	7	46.7	2.81	0.37	0.92	25.00	3.41	7.14
Lonchocarpus guatemalensis	*Fabaceae – Faboideae*	6	40.0	2.41	0.47	1.18	25.00	3.41	7.00
Bauhinia sp.	*Fabaceae – Caesalpinioideae*	9	60.0	3.61	0.79	1.96	8.33	1.14	6.71
Croton schiedeanus	*Euphorbiaceae*	3	20.0	1.20	0.20	0.50	25.00	3.41	5.12
Cojoba graciliflora	*Fabaceae – Mimosoideae*	5	33.3	2.01	0.76	1.89	8.33	1.14	5.04
Calyptranthes bartlettii	*Myrtaceae*	5	33.3	2.01	0.15	0.37	16.67	2.27	4.65
Cestrum nocturnum	*Solanaceae*	2	13.3	0.80	0.07	0.17	16.67	2.27	3.25
Eugenia sp. 3 (*Urban* 323)	*Myrtaceae*	2	13.3	0.80	0.07	0.17	16.67	2.27	3.25
Erythroxylum rotundifolium	*Erythroxylaceae*	2	13.3	0.80	0.04	0.09	16.67	2.27	3.17
Picramnia antidesma	*Picramniaceae*	2	13.3	0.80	0.03	0.09	16.67	2.27	3.16
Myrciaria floribunda	*Myrtaceae*	2	13.3	0.80	0.19	0.48	8.33	1.14	2.42
Guapira cf. *linearibracteata* (*Urban* 322)	*Nyctaginaceae*	2	13.3	0.80	0.06	0.14	8.33	1.14	2.08
Cassipourea guianensis	*Rhizophoraceae*	1	6.7	0.40	0.13	0.31	8.33	1.14	1.85
Miconia albicans	*Melastomataceae*	1	6.7	0.40	0.08	0.20	8.33	1.14	1.74

TABLE 2. (*Cont'd*).

Species	Family	Density			Dominance		Frequency		
		Ind.	ADen.	RDen.	ADo.	RelD.	AFreq.	RelF.	IVI
Sapindus saponaria	*Sapindaceae*	1	6.7	0.40	0.08	0.20	8.33	1.14	1.74
Acacia angustissima	*Fabaceae – Mimosoideae*	1	6.7	0.40	0.06	0.14	8.33	1.14	1.68
Eugenia sp. 2 (*Urban* 131)	*Myrtaceae*	1	6.7	0.40	0.05	0.12	8.33	1.14	1.66
Hampea stipitata	*Malvaceae*	1	6.7	0.40	0.04	0.11	8.33	1.14	1.64
Ardisia cf. *compressa* (*Urban* 293)	*Myrsinaceae*	1	6.7	0.40	0.04	0.09	8.33	1.14	1.63
Machaerium sp. 1 (*Urban* 162)	*Fabaceae – Faboideae*	1	6.7	0.40	0.04	0.09	8.33	1.14	1.63
Mouriri myrtilloides	*Memecylaceae*	1	6.7	0.40	0.04	0.09	8.33	1.14	1.63
Byrsonima crassifolia	*Malpighiaceae*	1	6.7	0.40	0.03	0.06	8.33	1.14	1.60
Hirtella racemosa	*Chrysobalanaceae*	1	6.7	0.40	0.03	0.06	8.33	1.14	1.60
Astrocaryum mexicanum	*Arecaceae*	1	6.7	0.40	0.02	0.06	8.33	1.14	1.59
Totals	21	249	1660.00	100	40.78	100	733.3	100	300

Ind., number of individuals recorded in plot; ADen., absolute density; RDen., relative density; ADo., absolute dominance; RelD., relative dominance; AFreq., absolute frequency (%); RelF., relative frequency; IVI, importance value index.

TABLE 3. Transition association (downstream right bank of Macal River): Phytosociological data

Species	Family	Density			Dominance		Frequency		
		Ind.	ADen.	RDen.	ADo.	RelD.	AFreq.	RelF.	IVI
Astrocaryum mexicanum	*Arecaceae*	5	33.3	6.17	2.83	28.81	50.00	5.88	40.87
Spondias mombin	*Anacardiaceae*	6	40.0	7.41	1.25	12.77	66.67	7.84	28.02
Ateleia gummifera	*Fabaceae – Faboideae*	9	60.0	11.11	0.84	8.60	66.67	7.84	27.56
Cochlospermum vitifolium	*Cochlospermaceae*	10	66.7	12.35	0.68	6.89	50.00	5.88	25.12
Zuelania guidonia	*Salicaceae*	7	46.7	8.64	0.89	9.09	50.00	5.88	23.61
Andira inermis subsp. *inermis*	*Fabaceae – Faboideae*	5	33.3	6.17	0.99	10.07	50.00	5.88	22.12
Bursera simaruba	*Burseraceae*	6	40.0	7.41	0.43	4.33	66.67	7.84	19.58
Vitex gaumeria	*Verbenaceae*	5	33.3	6.17	0.30	3.09	50.00	5.88	15.14
Eugenia sp. 2 (*Urban* 131)	*Myrtaceae*	5	33.3	6.17	0.07	0.70	50.00	5.88	12.75
Ficus insipida	*Moraceae*	3	20.0	3.70	0.12	1.21	50.00	5.88	10.80
Cordia alliodora	*Boraginaceae*	3	20.0	3.70	0.29	2.98	33.33	3.92	10.60
Lonchocarpus sp. (*Urban* 255)	*Fabaceae – Faboideae*	2	13.3	2.47	0.28	2.85	33.33	3.92	9.24
Helicteres guazumifolia (*Urban* 132)	*Malvaceae*	2	13.3	2.47	0.08	0.82	33.33	3.92	7.21
Erythroxylum guatemalense	*Erythroxylaceae*	2	13.3	2.47	0.06	0.60	33.33	3.92	6.99
Lonchocarpus rugosus	*Fabaceae – Faboideae*	2	13.3	2.47	0.05	0.55	33.33	3.92	6.94
Bauhinia sp. (*Urban* 30)	*Fabaceae – Mimosoideae*	1	6.7	1.23	0.36	3.70	16.67	1.96	6.89
Quercus purulhana	*Fagaceae*	2	13.3	2.47	0.05	0.49	16.67	1.96	4.92
Thevetia ahouai	*Apocynaceae*	1	6.7	1.23	0.11	1.09	16.67	1.96	4.29
Protium copal	*Burseraceae*	1	6.7	1.23	0.08	0.77	16.67	1.96	3.96
Randia lundelliana	*Rubiaceae*	1	6.7	1.23	0.02	0.16	16.67	1.96	3.36
Eugenia sp. 3 (*Urban* 256)	*Myrtaceae*	1	6.7	1.23	0.02	0.16	16.67	1.96	3.36
Croton xalapensis	*Euphorbiaceae*	1	6.7	1.23	0.01	0.13	16.67	1.96	3.33
Lasianthaea fruticosa	*Asteraceae*	1	6.7	1.23	0.01	0.13	16.67	1.96	3.33
Totals	19	81	540	100	9.83	100	850.00	100	300

Ind., number of individuals recorded in plot; ADen., absolute density; RDen., relative density; ADo., absolute dominance; RelD., relative dominance; AFreq., absolute frequency (%); RelF., relative frequency; IVI, importance value index.

TABLE 4. Oak-dominated savanna: Phytosociological data

Species	Family	Density			Dominance		Frequency		
		Ind.	ADen.	RDen.	ADo.	RelD.	AFreq.	RelF.	IVI
Quercus oleoides	*Fagaceae*	161	536.7	78.92	9.91	76.55	100.00	22.22	177.69
Byrsonima crassifolia	*Malpighiaceae*	18	60.0	8.82	1.41	10.89	100.00	22.22	41.93
Pinus caribaea var. *hondurensis*	*Pinaceae*	5	16.7	2.45	0.45	3.45	83.33	18.52	24.41
Quercus purulhana	*Fagaceae*	12	40.0	5.88	0.89	6.90	50.00	11.11	23.89
Andira inermis subsp. *inermis*	*Fabaceae – Faboideae*	4	13.3	1.96	0.16	1.23	50.00	11.11	14.30
Xylopia frutescens	*Annonaceae*	2	6.7	0.98	0.06	0.45	33.33	7.41	8.83
Lonchocarpus sp. (*Urban* 255)	*Fabaceae – Faboideae*	1	3.3	0.49	0.04	0.34	16.67	3.70	4.54
Acosmium panamense	*Fabaceae – Faboideae*	1	3.3	0.49	0.03	0.20	16.67	3.70	4.40
Totals	5	204	680.00	100	12.95	100	450.0	100	300

Ind., number of individuals recorded in plot; ADen., absolute density; RDen., relative density; ADo., absolute dominance; RelD., relative dominance; AFreq., absolute frequency (%); RelF., relative frequency; IVI, importance value index.

Results of quantitative sampling in the oak-dominated savanna reveal only eight woody species recorded from a total of 204 individuals. *Quercus oleoides* dominates the community and has by far the greatest IVI of all species (IVI = 177.69). *Byrsonima crassifolia* has the second greatest IVI in the sample (IVI = 41.93). *Pinus caribaea* var. *hondurensis* and *Quercus purulhana* are also common in the association.

Discussion

This study indicates that the riparian vegetation along the Macal is floristically diverse, with over 200 species recorded along a narrow 1.5 km stretch of the river. This figure represents 7% of the flora of Belize as defined by Balick *et al.* (2000). By contrast, the woody flora of oak-dominated savanna is species-poor.

The vegetation in the river channel was sparse and dominated by ruderal species, with none of the woody taxa exceeding 1.5 m in height. The intermittent floods that characterize the hydraulic regime of the Macal River are the most likely factors preventing the development of more structurally complex communities in the channel. A few taxa in the riverine corridor can be viewed as specialists, exhibiting limited distributions and being confined to specific zones in the river channel. Examples of specialized taxa include *Najas wrightiana* and *Marathrum* sp. which grow only on inundated rocks within the fast-flowing stream channel, and *Inga vera* subsp. *vera* and *Calyptranthes bartlettii*. The latter two species are able to withstand frequent inundation and occurred only on islands in the river channel and in the fringing riverine vegetation.

Inga vera subsp. *vera* is the most common tree species along the banks of the river and its presence effectively defines the riparian vegetation here. This species is a common component of riverine vegetation in the Neotropics and is widespread from Mexico to coastal Ecuador (Pennington, 1997). Although *Inga vera* subsp. *vera* and a number of other common species such as *Pleuranthodendron lindenii* and *Calyptranthes lindeniana* dominate the riparian vegetation there is considerable floristic heterogeneity along the river. Examination of plot data in the fringing riverine vegetation reveals that each individual plot varies considerably in its species assemblages. These findings are in line with the work of numerous riparian ecologists who have noted similar variation in vegetation along river corridors (Hupp, 1982; Carbiener & Schnitzler, 1990; Decamps & Tabacchi, 1994; Malanson, 1993).

Clear floristic differences were observed between the fringing riverine vegetation on either side of the river channel. For example, very common genera on the downstream left bank of the river included species of *Piper* and *Costus*; these are entirely absent from the downstream right side of the river. Other species apparently confined to the left bank include *Bactris major* var. *major*, *Chamaedorea ernesti-augustii* and *C. oblongata*. Floristic differences in the fringing riverine vegetation on either side of the river relate to geological differences between the uplands on either side of the channel: for example, *Chamaedorea ernesti-augustii* is known to prefer limestone

areas. Tree species known to occur widely in the Chiquibul forest and which appear confined to the downstream left bank at this site include *Castilla elastica* subsp. *elastica*, *Ceiba pentandra* and *Attalea cohune.* All of these are characteristic of subtropical forests on better soils in Belize, with *Attalea cohune* characteristic of disturbed sites (Henderson *et al.*, 1995). Taxa known to occur on the poorer soils of the Mountain Pine Ridge and which appear to be confined to the downstream right bank include *Miconia albicans* and *Byrsonima crassifolia*. Both these species are characteristic of the oligotrophic soils of neotropical savannas (Lenthall *et al.*, 1999).

The transition community on the downstream right bank of the Macal River is species-rich and structurally heterogeneous. Although *Astrocaryum mexicanum* has the highest IVI of all species sampled (IVI = 40.87), the community lacks clearly dominant species. Instead a suite of more or less equally co-dominant taxa comprise the majority of individuals sampled.

The oak-dominated savanna is structurally homogeneous and species-poor compared with all the other communities sampled. *Quercus oleoides* was clearly the dominant species forming the upper canopy in the community. The association had the appearance of an open woodland, with grasses forming a relatively well-developed herbaceous layer typical of a tropical savanna.

The high overall diversity of the Macal River undoubtedly reflects the diverse array of habitats associated with it. These include dry upland sites, terraced rocky slopes, inundated floodplains, recent alluvial deposits, quagmire anaerobic soils, gravel bars, and islands in the river channel. Flooding events are primarily responsible for creating its spatial heterogeneity, with the timing of flooding, its duration, frequency and magnitude all identified as influencing the structure and composition of riverine vegetation (Poff *et al.*, 1997; Richter *et al.*, 1997; Ward *et al.*, 1999).

One of the most significant threats to riverine vegetation in the region is the proposed Chalillo Dam. This project has already flooded the valley upstream from Chalillo to a depth of 400 m and inundated approximately 18 km of riverine habitat on the Macal River and 15 km on the Rascapulo. In addition, it is highly likely that vegetation downstream from the dam will be affected. Although the precise effects of the dam on the riverine vegetation cannot be predicted, its construction is likely to have substantial ecological consequences for the region. Dams are known to alter the hydraulic regime of rivers and change the timing, duration, frequency and magnitude of floods (Kalliola & Puhakka, 1988; Malanson, 1993; Johansson *et al.*, 1996; Nilsson & Berggran, 2000; Nilsson & Svedmark, 2002). Such alterations to the flow regime reduce the meandering of the channel and result in the loss of spatial heterogeneity in the riparian corridor (Johansson *et al.*, 1996).

Results of this study indicate that the vegetation formations associated with the Macal River are botanically diverse, and include a Belizean endemic. These findings support the work of other authors such as Minty (2001) that these communities are ecologically important, and of considerable conservation value. With the construction of the Chalillo Dam, the future of this riparian habitat is uncertain. The establishment of permanent monitoring plots downstream from the inundated

areas is recommended. These could provide a valuable opportunity to improve our understanding of how dams impact on downstream riverine vegetation.

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APPENDIX

Species list with voucher numbers for the Macal River and associated vegetation communities

HA, habit; HAB, habitat; VOU, voucher.
Habit codes: h, herb; s, shrub; t, tree; v, vine; e, epiphyte.
Habitat codes: a, aquatic; rc, riverine channel; fr, fringing riverine; rt, riverine transition; s, savanna.

	HA	HAB	VOU
SPERMATOPHYTA			
Acanthaceae			
Aphelandra scabra (Vahl) Sm.	s	rt	*Urban* 151 (E)
Blechum pyramidatum (Lam.) Urb.	h	fr	*Urban* 401 (E)
Dicliptera sexangularis (L.) Juss.	h	fr	*Urban* 83 (E)
Justicia breviflora (Nees) Rusby	h	fr	*Urban* 88 (E)
Justicia spicigera Schltdl.	s	rt	*Urban* 388 (E)
Odontonema callistachyum (Schltdl. & Cham.) Kuntze	s	fr	*Urban* 110 (E)
Odontonema tubaeforme (Bertol.) Kuntze	s	fr	*Urban* 291 (E)
Ruellia geminiflora Kunth	h	fr/rt	*Urban* 70 (E)
Amaranthaceae			
Gomphrena serrata L.	h	fr	*Urban* 231 (E)
Anacardiaceae			
Metopium brownei (Jacq.) Urb.	t	rt	*Urban* 266 (E)
Spondias mombin L.	t	rt	*Urban* 265 (E)
Annonaceae			
Xylopia frutescens Aubl.	t	rt	*Urban* 347 (E)
Apocynaceae			
Allamanda cathartica L.	s	fr	*Dwyer* 12283 (MO)
Thevetia ahouai (L.) A.DC.	s	rt	*Urban* 258 (E)
Araceae			
Anthurium schlechtendalii Kunth subsp. *schlechtendalii*	h	rt	*Urban* 247 (E)
Philodendron dwyeri Croat	h	rt	*Dwyer* 12334 (MO)
Philodendron radiatum Schott var. *radiatum*	h/e	fr	*Urban* 203 (E)
Syngonium podophyllum Schott	h/e	fr	*Urban* 210 (E)
Araceae sp. 1	h	fr	*Urban* 121 (E)
Araceae sp. 2	h	fr	*Urban* 155 (E)
Araliaceae			
Dendropanax arboreus (L.) Decne. & Planch.	t	fr	*Urban* 175 (E)
Oreopanax obtusifolius L.O.Williams	t	rt	*Urban* 269 (E)
Arecaceae			
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	p	rt	No voucher
Astrocaryum mexicanum Liebm. ex Mart.	p	fr/rt	No voucher
Attalea cohune Mart.	p	rt	No voucher
Bactis major Jacq. var. *major*	p	rt	No voucher
Chamaedorea ernesti-angustii H.Wendl.	p	rt	No voucher

Chamaedorea oblongata Mart.	p	rt	No voucher
Chamaedorea tepejilote Liebm.	p	rt	No voucher
Cryosophila stauracantha (Heynh.) R.Evans	p	rt	*Urban* 292 (E)
Desmoncus orthacanthos Mart.	p	rt	*Urban* 394 (E)
Asteraceae			
Acmella filipes (Greenm.) R.K.Jansen	h	rt	*Dwyer* 10165 (MO)
Ageratum houstonianum Mill.	h	fr	*Urban* 61 (E)
Ageratum peckii B.L.Rob.	h	rt	*Dwyer* 12318 (MO)
Chromolaena glaberrima (DC.) R.M.King & H.Rob.	h	rt	*Dwyer* 12278 (MO)
Lasianthaea fruticosa (L.) K.M.Becker	t	rt	*Urban* 257 (E)
Melampodium costaricense Steussy	h	fr	*Urban* 97 (E)
Smallanthus uvedalius (L.) Mack. ex Small	h	fr	*Urban* 86 (E)
Sphagneticola trilobata (L.) Pruski	h	fr	*Urban* 49 (E)
Symphyotrichum expansum (Poepp. & Spreng.) G.L.Nesom	h	rc	*Urban* 24 (E)
Bignoniaceae			
Amphilophium paniculatum (L.) Kunth	v	fr/rt	*Urban* 239 (E)
Paragonia pyramidata (Rich.) Bureau	v	fr/rt	*Urban* 396 (E)
Pithecoctenium crucigerum (L.) A.H.Gentry	v	rt	*Dwyer* 12332A (MO)
Pseudocatalpa caudiculata (Standl.) A.H.Gentry	v	t	*Urban* 428 (E)
Tynanthus guatemalensis Donn.Sm.	v	rt	*Dwyer* 10189 (MO)
Boraginaceae			
Cordia alliodora (Ruiz & Pav.) Oken.	t	rt	No voucher
Bromeliaceae			
Tillandsia sp.	h	rt	*Urban* 237 (E)
Burseraceae			
Bursera simaruba (L.) Sarg.	t	rt	*Urban* 241 (E)
Protium copal (Schltdl. & Cham.) Engl.	t	rt	*Urban* 254 (E)
Buxaceae			
Buxus barlettii Standl.	s	rt	*Urban* 45 (E)
Campanulaceae			
Lobelia cardinalis L.	h	rc	*Urban* 359 (E)
Lobelia xalapensis Kunth	h	rt	*Dwyer* 12332 (MO)
Cannabaceae			
Celtis iguanaea (Jacq.) Sarg.	s	fr	*Urban* 313 (E)
Celastraceae			
Hippocratea volubilis L.	v	fr	*Urban* 164 (E)
Chrysobalanaceae			
Hirtella racemosa Lam.	t	fr	*Urban* 156 (E)
Clusiaceae			
Clusia guatemalensis Hemsl.	t	fr	*Urban* 200 (E)
Clusia sp.	t	fr	*Urban* 199 (E)
Vismia camparaguey Sprague & L.Riley	s	fr/rt	*Urban* 168 (E)
Cochlospermaceae			
Cochlospermum vitifolium (Willd.) Spreng.	t	rt	*Urban* 235 (E)

Combretaceae			
Bucida burceras L.	t	fr	*Urban* 194 (E)
Commelinaceae			
Commelina diffusa Burm.f.	h	fr	*Urban* 93 (E)
Tradescantia zanoria (L.) Sw.	h	fr	*Urban* 303 (E)
Tripogandra serrulata (Vahl) Handlos	h	fr	*Urban* 77 (E)
Convolvulaceae			
Ipomoea cf. *umbraticola* House	v	rc/fr	*Urban* 90 (E)
Merremia cissoides (Griseb.) Hallier f.	v	fr/rt	*Urban* 275 (E)
Costaceae			
Costus cf. *pictus* D.Don	h	fr	*Urban* 290 (E)
Cucurbitaceae			
Melothria pedula L.	v	fr	*Urban* 75 (E)
Momordica charantia L.	v	fr	*Urban* 66 (E)
Cyclanthaceae			
Asplundia sp.	h	rt	*Urban* 74 (E)
Cyperaceae			
Cyperus articulatus L. var. *articulatus*	h	fr	*Urban* 103 (E)
Cyperus digitatus Roxb.	h	fr	*Urban* 38 (E)
Cyperus haspan L.	h	fr	*Urban* 331 (E)
Cyperus ligularis L.	h	fr	*Urban* 224 (E)
Eleocharis elegans (Kunth) Roem. & Schult.	h	rc	*Dwyer* 12328 (MO)
Eleocharis interstincta (Vahl) Roem. & Schult.	h	rc	*Urban* 98 (E)
Eleocharis retroflexa (Poir.) Urb.	h	rc	*Urban* 23 (E)
Fimbristylis dichotoma (L.) Vahl	h	rc	*Urban* 362 (E)
Rhynchospora cephalotes (L.) Vahl	h	fr	*Urban* 196 (E)
Rhynchospora nervosa (Vahl) Boeckeler	h	rt	*Urban* 272 (E)
Scleria latifolia Sw.	h	fr	*Urban* 391 (E)
Scleria cf. *melaleuca* Rchb. ex Schltdl. & Cham.	h	fr	*Urban* 50 (E)
Dilleniaceae			
Davilla kunthii A.St.-Hil.	s	rt	No voucher
Doliocarpus dentatus (Aubl.) Standl. subsp. *dentatus*	v	fr	*Urban* 185 (E)
Dioscoreaceae			
Dioscorea sp.	v	fr	*Urban* 312 (E)
Erythroxylaceae			
Erythroxylum guatemalense Lundell	s	rt	*Urban* 244 (E)
Erythroxylum rotundifolium Lunan	s	fr	*Urban* 144 (E)
Euphorbiaceae			
Acalypha arvensis Poepp.	s	fr	*Urban* 64 (E)
Acalypha diversifolia Jacq.	t	fr	*Urban* 218 (E)
Acalypha leptopoda Müll.Arg.	h	fr	*Urban* 29 (E)
Acalypha villosa Jacq.	s	fr	*Urban* 33 (E)
Acalypha sp.	s	fr	*Urban* 126 (E)
Adelia barbinervis Schltdl. & Cham.	t	fr	*Urban* 31 (E)

Chamaesyce hypericifolia (L.) Millsp.	h	rt	*Dwyer* 10759 (MO)
Chamaesyce thymifolia (L.) Millsp.	h	rt	*Spellman* 1390 (MO)
Cnidoscolus aconitifolius (Mill.) I.M.Johnst.	t	fr	*Urban* 400 (E)
Cnidoscolus schiedeanus Schltdl.	t	fr	*Urban* 217 (E)
Croton xalapensis Kunth	t	fr	*Urban* 40 (E)
Euphorbia sp.	h	fr	*Urban* 91 (E)
Ricinus communis L.	h	fr	*Urban* 87 (E)
Fabaceae – Faboideae			
Acosmium panamense (Benth.) Yakovlev	t	rt	*Urban* 349 (E)
Andira inermis (W.Wright) DC. subsp. *inermis*	t	fr/rt	*Urban* 28 (E)
Ateleia gummifera (DC.) D.Dietr.	t	rt	*Urban* 202 (E)
Centrosema sp.	v	fr/rt	*Urban* 53 (E)
Crotalaria cajanifolia Kunth	h	fr	*Urban* 85 (E)
Desmodium incanum DC.	h	fr	*Urban* 143 (E)
Lonchocarpus guatemalensis Benth.	t	fr/rt	*Urban* 36 (E)
Lonchocarpus rugosus Benth.	s/t	fr/rt	*Urban* 167 (E)
Lonchocarpus sp.	t	fr/rt	*Urban* 255 (E)
Machaerium sp.	v	fr	*Urban* 162 (E)
Mucuna sp.	v	fr	*Urban* 73 (E)
Rhynchosia sp.	v	fr	*Urban* 67 (E)
Vigna luteola (Jacq.) Benth.	v	fr	*Urban* 84 (E)
Fabaceae – Mimosoideae			
Acacia angustissima (Mill.) Kuntze	t	fr	*Urban* 130 (E)
Acacia gentlei Standl.	t	fr	*Urban* 105 (E)
Calliandra tergemina (L.) Benth. var. *emarginata* (Willd.) Barneby	s	rc/fr	*Urban* 148 (E)
Cojoba graciliflora (S.F.Blake) Britton & Rose	t	fr	*Urban* 114 (E)
Inga vera Willd. subsp. *vera*	t	rc/fr	*Urban* 26 (E)
Mimosa hondurana Britton	v	fr	*Urban* 95 (E)
Mimosa pellita Humb. & Bonpl. ex Willd. var. *pellita*	s	rc/fr	*Urban* 94 (E)
Mimosa somnians Humb. & Bonpl. ex Willd. subsp. *somnians* var. *somnians*	v	fr	*Urban* 63 (E)
Fabaceae – Caesalpinioideae			
Bauhinia sp.	s	rc/fr	*Urban* 30 (E)
Bauhinia ungulata L.	s	rt	*Dwyer* 12285 (MO)
Schizolobium parahyba (Vell.) S.F.Blake	t	rt	No voucher
Senna cobanensis (Britton & Rose) H.S.Irwin & Barneby	s	rt	*Spellman* 1397 (MO)
Fagaceae			
Quercus oleoides Schltdl. & Cham.	t	rt/s	*Urban* 333 (E)
Quercus purulhana Trel.	t	s	*Urban* 267 (E)
Gentianaceae			
Schultesia lisianthoides (Griseb.) Benth. & Hook.f. ex Hemsl.	h	fr	*Urban* 191 (E)
Gesneriaceae			
Achimenes erecta (Lam.) H.P.Fuchs	h	fr	*Dwyer* 12324 (MO)
Hydrocharitaceae			
Najas wrightiana A.Braun	h	a	*Urban* 405 (E)

Lamiaceae			
Salvia urica Epling	h	fr/rt	*Urban* 41 (E)
Vitex gaumeria Greenm.	t	fr/rt	*Urban* 79 (E)
Lauraceae			
Nectandra salicifolia (Kunth) Nees	t	fr	*Urban* 13 (E)
Loranthaceae			
Phthirusa pyrifolia (Kunth) Eichler	v	fr	*Urban* 220 (E)
Lythraceae			
Cuphea calophylla Cham. & Schltdl.	h	rc	*Urban* 25 (E)
Cuphea decandra Aiton var. *purpusii* (Brandegee) Bacig.	s	rc	*Dwyer* 10750 (MO)
Cuphea utriculosa Koehne	h	rc	*Urban* 21 (E)
Malpighiaceae			
Bunchosia lindeniana A.Juss.	s	rt	*Urban* 415 (E)
Byrsonima crassifolia (L.) Kunth	t	fr/rt/s	*Urban* 157 (E)
Heteropterys laurifolia (L.) A.Juss.	s	fr	*Urban* 170 (E)
Stigmaphyllum ellipticum (Kunth) A.Juss.	v	rt	*Urban* 278 (E)
Malvaceae			
Byttneria aculeata (Jacq.) Jacq.	v	fr	*Urban* 71 (E)
Ceiba pentandra (L.) Gaertn.	v	rt	No voucher
Hampea stipitata S.Watson	s	fr	*Urban* 301 (E)
Hampea trilobata Standl.	t	rt	*Urban* 268 (E)
Helicteres guazumifolia Kunth	s	rt	*Urban* 132 (E)
Herissantia crispa (L.) Brizicky	h	fr	*Urban* 81 (E)
Luehea speciosa Willd.	t	fr	*Urban* 338 (E)
Melochia lupulina Sw.	s	fr	*Urban* 134 (E)
Waltheria indica L.	h	fr	*Urban* 68 (E)
Marantaceae			
Calathea lutea (Aubl.) G.Mey.	h	fr	*Urban* 319 (E)
Calathea sp.	h	fr	*Urban* 122 (E)
Maranta gibba Sm.	h	fr	*Urban* 76 (E)
Melastomataceae			
Arthrostemma parvifolium Cogn.	h	fr	*Urban* 135 (E)
Miconia albicans (Sw.) Triana	s	fr/rt/s	*Urban* 115 (E)
Miconia prasina (Sw.) DC.	s	fr	*Urban* 193 (E)
Memecylaceae			
Mouriri myrtilloides (Sw.) Poir. subsp. *parvifolia* (Benth.) Morley	t	fr	*Urban* 160 (E)
Moraceae			
Castilla elastica Sessé subsp. *elastica*	sap	fr	*Urban* 314 (E)
Ficus insipida Willd.	t	fr	*Urban* 117 (E)
Myrsinaceae			
Ardisia compressa Kunth	s	fr	*Urban* 111 (E)
Parathesis sp. 1	t	fr	*Urban* 47 (E)
Parathesis sp. 2	t	fr	*Urban* 109 (E)

Myrtaceae			
Calyptranthes bartlettii Standl.	s	rc/fr	*Urban* 22 (E)
Calyptranthes lindeniana O.Berg	s	rc/fr	*Urban* 112 (E)
Eugenia vacana Lundell	s	fr	*Dwyer* 10747 (MO)
Eugenia sp. 1	s	fr	*Urban* 131 (E)
Eugenia sp. 2	s	fr	*Urban* 323 (E)
Eugenia sp. 3	t	rt	*Urban* 256 (E)
Myrciaria floribunda (H.West ex Willd.) O.Berg	s	fr	*Urban* 181 (E)
Nyctaginaceae			
Guapira linearibracteata (Heimerl) Lundell	t	fr	*Urban* 322 (E)
Ochnaceae			
Ouratea nitida (Sw.) Engl.	t	fr	*Urban* 188 (E)
Onagraceae			
Ludwigia octavalis (Jacq.) P.H.Raven	s	rc	*Urban* 368 (E)
Orchidaceae			
Habenaria monorrhiza (Sw.) Rchb.f.	h	rt	*Dwyer* 12279 (MO)
Oxalidaceae			
Biophytum dendroides (Kunth) DC.	h	rc	*Urban* 223 (E)
Oxalis frutescens L. subsp. *angustifolia* (Kunth)	h	fr	*Urban* 51 (E)
Papaveraceae			
Argemone mexicana L.	h	fr	*Urban* 39 (E)
Passifloraceae			
Passiflora foetida L.	v	rt	*Urban* 279 (E)
Passiflora guatemalensis S.Watson	v	rt	*Urban* 382 (E)
Passiflora xiikzodz J.M.MacDougal subsp. *xiikzodz*	v	fr	*Urban* 54 (E)
Phyllanthaceae			
Phyllanthus cf. *compressus* Kunth	h	rc	*Urban* 366 (E)
Picramniaceae			
Picramnia antidesma Sw.	t	fr	*Urban* 297 (E)
Piperaceae			
Piper amalago L.	s	fr	*Urban* 107 (E)
Piper jacquemontianum Kunth	s	fr	*Urban* 302 (E)
Piper hispidum Sw.	s	fr	*Urban* 309 (E)
Plantaginaceae			
Mecardonia procumbens (Mill.) Small	s	rc	*Urban* 18 (E)
Scoparia dulcis L.	h	rt	*Dwyer* 10761 (MO)
Poaceae			
Arundinella berteroniana (Schult.) Hitchc. & Chase	h	rc/fr	*Urban* 16 (E)
Cryptochloa stricliflora (E.Fourn.) Swallen	h	rc/fr	*Urban* 304 (E)
Eragrostis sp.	h	rc	*Urban* 363 (E)
Hymenache amplexicaulis (Rudge) Nees	h	rc/fr	*Urban* 27 (E)
Lasiacis rugelii (Griseb.) Hitchc. var. *rugelli*	h	fr	*Urban* 166 (E)
Olyra latifolia L.	h	fr	*Urban* 320 (E)
Oplismenus hirtellus (L.) P.Beauv.	h	fr	*Urban* 389 (E)

Panicum laxum Sw.	h	rc	*Urban* 364 (E)
Tripsacum latifolium Hitchc.	h	fr	*Urban* 58 (E)
Podostemaceae			
Marathrum sp.	h	a	*Urban* 427 (E)
Polygalaceae			
Bredemeyera lucida (Benth.) Klotzsch. ex Hassk.	s	fr	*Urban* 404 (E)
Polygala paniculata L.	h	rc	*Urban* 19 (E)
Polygala sp.	h	rc	*Urban* 72 (E)
Polygonaceae			
Coccoloba belizensis Standl.	t	fr	*Urban* 184 (E)
Polygonum persicarioides Kunth	h	fr	*Urban* 226 (E)
Polygonum punctatum Elliott	h	fr	*Urban* 82 (E)
Primulaceae			
Anagallis pumila Sw.	h	fr	*Dwyer* 12330 (MO)
Proteaceae			
Roupala montana Aubl.	s	fr	*Urban* 154 (E)
Rhizophoraceae			
Cassipourea guianensis Aubl.	t	fr	*Urban* 347 (E)
Rosaceae			
Photinia microcarpa Standl.	t	fr	*Urban* 173 (E)
Rubiaceae			
Guettarda deamii Standl.	s	fr	*Urban* 129 (E)
Guettarda macrosperma Donn.Sm.	s	fr	*Urban* 35 (E)
Hamelia halycosa Donn.Sm.	s	rt	*Dwyer* 10179 (MO)
Hamelia patens Jacq. var. *patens*	s	fr	*Urban* 171 (E)
Lindenia rivalis Benth.	s	rc	*Urban* 177 (E)
Mitracarpus hirtus (L.) DC.	h	rt	*Dwyer* 10171 (MO)
Morinda panamensis Seem.	s	fr	*Urban* 403 (E)
Oldenlandia corymbosa L.	h	rt	*Dwyer* 12331 (MO)
Psychotria costivenia Griseb.	s	rt	*Urban* 139
Psychotria mexicae Standl.	s	rt	*Dwyer* 10193 (MO)
Psychotria nervosa Sw.	s	fr	*Urban* 43 (E)
Psychotria poeppigiana Müll.Arg.	s	fr	*Urban* 392 (E)
Psychotria pubescens Sw.	s	rt	*Dwyer* 11557 (MO)
Randia lundelliana Standl.	s	fr	*Urban* 145 (E)
Spermacoce verticillata L.	h	rc	*Urban* 17 (E)
Salicaceae			
Casearia corymbosa Kunth	s	fr	*Urban* 32 (E)
Pleuranthodendron lindenii (Turcz.) Sleumer	t	fr	*Urban* 284 (E)
Prockia crucis L.	s	rt	*Urban* 240 (E)
Zuelania guidonia (Sw.) Britton & Millsp.	t	rt	*Urban* 259 (E)
Sapindaceae			
Cardiospermum grandiflorum Sw.	v	fr	*Urban* 289 (E)
Paullinia cf. *pinnata* L.	v	fr	*Urban* 390 (E)

Paullinia sp.	v	fr	*Urban* 163 (E)
Sapindus saponaria L.	t	fr	*Urban* 180 (E)
Serjania lundellii Croat	v	rc/fr	*Urban* 230 (E)
Sapotaceae			
Chrysophyllum mexicanum Brandegee ex Standl.	s	fr	*Urban* 125 (E)
Smilacaceae			
Smilax sp.	v	fr	*Urban* 150 (E)
Smilax velutina Killip & C.V.Morton	v	rf	*Dwyer* 12275 (MO)
Solanaceae			
Capsicum annuum L. var. *glabriusculum* (Dunal) Heiser & Pickersgill	h	fr	*Urban* 308 (E)
Cestrum nocturnum L.	s	fr	*Urban* 296 (E)
Solanum erythrotrichum Fernald	h	fr	*Urban* 315 (E)
Solanum torvum Sw.	s	fr	*Dwyer* 10751 (MO)
Theophrastaceae			
Deherainia smaragdina (Planch. & Linden) Decne. subsp. *smaragdina*	s	fr	*Urban* 393 (E)
Turneraceae			
Turnera aromatica Arbo	s	fr	*Urban* 59 (E)
Ulmaceae			
Ampelocera hottlei (Standl.) Standl.	t	fr	*Urban* 104 (E)
Urticaceae			
Cecropia obtusifolia Bertol.	t	rt	No voucher
Pilea microphylla (L.) Liebm.	h	rc	*Urban* 352 (E)
Verbenaceae			
Citharexylum caudatum L.	s	fr	*Urban* 48 (E)
Lantana camara L.	s	rt	*Urban* 243 (E)
Stachytarpheta cayennensis (Rich.) Vahl	s	rt	*Urban* 60 (E)
Violaceae			
Hybanthus oppositifolius (L.) Taub.	h	fr	*Urban* 52 (E)
Vitaceae			
Vitis tiliifolia Humb. & Bonpl. ex Roem. & Schult.	h	fr	*Urban* 212 (E)
PINOPHYTA			
Pinaceae			
Pinus caribaea Morlet var. *hondurensis* (Sénéclauze) W.H.Barrett & Golfari	t	s	No voucher
LYCOPODIOPHYTA			
Selaginellaceae			
Selaginella pallescens (C.Presl) Spring	h	fr	*Urban* 140 (E)
Selaginella umbrosa Lem. ex Hieron.	h	fr	*Urban* 385 (E)

POLYPODIOPHYTA

Adiantaceae			
Adiantum latifolium Lam.	h	fr	*Urban* 205 (E)
Adiantum trapeziforme L.	h	fr	*Urban* 395 (E)
Aspleniaceae			
Tectaria mexicana (Feé) Morton	h	fr	*Urban* 189 (E)
Blechnaceae			
Blechnum occidentale L.	h	fr	*Urban* 206 (E)
Schizaeaceae			
Lygodium heterodoxum Kunze	v	fr	*Urban* 215 (E)
Lygodium venustrum Sw.	v	fr	*Urban* 152 (E)
Thelypteridaceae			
Thelypteris hispidula (Decne.) C.F.Reed	h	fr	*Urban* 207 (E)